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- **Tanaka, Katsunori, Takasago Machinery Works
Arai-cho, Takasago-shi, Hyogo-ken (JP)**
- **Ikegami, Yasuhiko, Takasago R&D Center
Arai-cho, Takasago-shi, Hyogo-ken (JP)**
- **Ono, Masaki, Takasago R&D Center
Arai-cho, Takasago-shi, Hyogo-ken (JP)**
- **Ikeda, Kazufumi, Takasago R&D Center
Arai-cho, Takasago-shi, Hyogo-ken (JP)**

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(71) Applicant: **Mitsubishi Heavy Industries, Ltd.
Tokyo (JP)**

(74) Representative: **Henkel, Feller, Hänzel
Möhlstrasse 37
81675 München (DE)**

(72) Inventors:
• **Matsuyama, Kelsuke, Takasago R&D Center
Arai-cho, Takasago-shi, Hyogo-ken (JP)**

(54) **Gasturbine and the combustor thereof**

(57) A gas turbine and the combustor thereof in which super high frequency combustion oscillation and the generation of NOx are reduced.

The fluctuation in pressure which induces the fluctuation in heat liberation is suppressed in the gas turbine combustor comprising a plurality of main fuel supply

nozzles (12a), each having a premixing nozzle (14) at the top end part thereof, by providing in the space upstream from the premixing nozzles partition elements (35) for dividing the space along the axis of the combustor or a honeycomb element having air passages in the axial direction, or by providing premixing nozzles composed of cylindrical elements with many holes (14a).

Fig 1 (A)

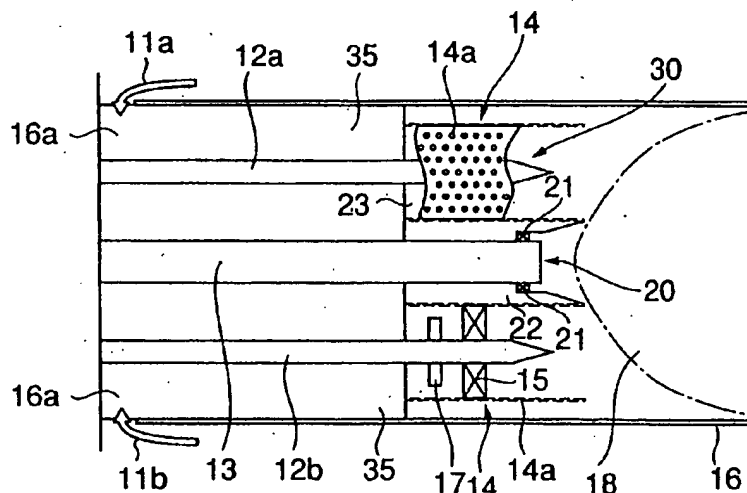
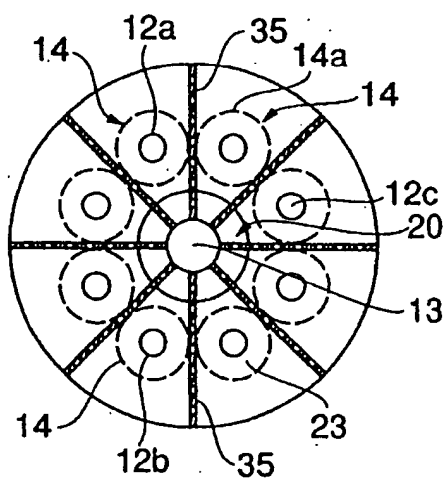


Fig 1 (B)



Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a gas turbine and the combustor thereof with reduced super high frequency oscillation of combustion and with reduced emission of NOx.

Description of the Related Art

[0002] FIG.6 is a longitudinal sectional view near the combustor of a gas turbine equipped with a conventional combustor. The conventional combustor will be explained here with reference to the drawing. In FIG.6, reference numeral 101 is a combustor mounted to a rotor housing 102.

[0003] The combustor 101 has a fuel supply nozzle 103, a liner (flame tube) 104, and a tail tube 105. Reference numeral 106 is an outer casing. A bypass elbow 107 is attached to the tail tube 105. Reference numeral 108 is a bypass valve and 109 is an adjusting mechanism of the bypass valve 108.

[0004] Reference numeral 110 is an air compressor. The compressed air 111 discharged from the compressor 110 flows inside the rotor housing 102, passes around the combustor 101 as indicated by arrows, and introduced into the combustor 101 as combustion air from the upstream side of the fuel supply nozzle 103.

[0005] The combustor 101 shown in FIG.6 is composed as described above, the fuel supplied through the fuel supply nozzles 103 is burnt, and the combustion gas is transmitted to the turbine blade part 112 to drive the turbine rotor.

[0006] The gas turbine is operated in a wide range of load and speed from start to the rated output. Therefore, it is required that the fuel is burned stable in the combustor of the gas turbine responding to the wide range of operation conditions such as air and fuel flow rate from the start to rated output.

[0007] Also, in order to reduce Nitrogen Oxide (Nox) discharged from the gas turbine combustor, a method capable of suppressing the Nox emission is strongly required.

[0008] Premixed combustion is a method of combustion to reduce the generation of NOx. In large, NOx generation increases exponentially with combustion flame temperature. By allowing the fuel to burn in a state of premixed combustion, local elevation of the combustion flame temperature can be prevented. Therefore, NOx emission can be reduced by lowering the combustion flame temperature through obtaining a lean mixture by increasing the ratio of air to fuel. Recently, to meet with the requirement for much further reduction in NOx emission, the proportion operated in lean premixed combustion is increasing.

[0009] However, in lean premixed combustion, generally a flame blowout is easy to occur compared with diffusive combustion in which fuel burns while mixing with air, and also combustion oscillation is easy to occur.

Also, the stable operation is limited. Therefore, it is necessary to attain the reduction of NOx emission while securing stable combustion that diffusive combustion and lean premixed combustion are combined properly.

[0010] FIG.4 shows schematically a structure of the conventional combustor in which diffusive combustion and lean premixed combustion is properly combined. Here, the structure will be briefly explained. The combustor is composed of a pilot burner 01 for diffusive combustion provided on the center axis of a substantially cylindrical flame tube(liner) 6, the pilot burner 01 being provided with a pilot fuel supply nozzle 3 having a pilot swirler vane 01a attached around the top end part of the pilot fuel supply nozzle 3; and premixed combustion burners 02 having eight main fuel supply nozzles 2a, ... arranged surrounding the pilot burner 01, premixing nozzles 4a, being arranged around the top end part each of the main fuel supply nozzles 2a, ..., a disk-like nozzle plate 7 and a premixing swirler vane 5, being provided annular space between each of the main fuel supply nozzles 2a, ... and premixing nozzles 4a,

[0011] In a combustor like this, pilot fuel is supplied from the pilot fuel supply nozzle 3, combustion air for burning the pilot fuel is supplied from around the pilot nozzle to effect pilot combustion which is of diffusive flame(hereunder referred to as pilot flame) in the central part of the combustor. Around the pilot flame is supplied fuel/air mixture of very high air excess ratio to be contacted with the high temperature gas of the pilot flame so as to effect main combustion composed of premixed flames(hereunder referred to as main flames).

[0012] The premixed combustion burners 02 are arranged surrounding the pilot burner 01 to allow the premixed combustion burners 02 to be located adjacent to the pilot burner 01, so the mixture spraying from the premixing nozzle 4a, ... mixes with the diffusive combustion flames of the pilot combustion, which dispersed by the swirling flow effected by the pilot swirler 01a, to be burned continually, the combustion air flow rate for the pilot burner 01 can be reduced, and the rate of premixed combustion can be increased resulting in reduced NOx emission.

[0013] In the drawing, reference numerals 1a and 1b show airflow, 8 shows combustion flame, 9 shows a node line of sound pressure(nodes of sound pressure: ND)).

[0014] However, with the prior art described above, combustion oscillation of very high frequency(super high-frequency combustion oscillation) which forms the acoustic mode(sound pressure mode) in the plane transversal to axis of the combustor occurs due to the coupling of the acoustic system and combustion system.

[0015] Currently, the super high-frequency combustion

tion oscillation is suppressed by enhancing the effect of damping in the acoustic system, for example, by providing a cylindrical element with many holes 10 in the combustion zone 8 along the inner circumference of the flame tube 6, as shown in FIG. 5. However, as the cylindrical element with many holes 10 is located in the high temperature zone of combustion, design consideration of heat resistance and cooling of the cylinder is inevitable, which results in complicated structure and increased manufacturing cost.

[0016] There are the cases the combustor has not only one node line (1ND) but a plurality of node lines of higher order of sound mode as shown in FIG. 3.

[0017] For example, FIG. 3(A) shows the case in which there are two node lines of 2nd order which partition the plane transversal to the axis of the combustor into four vibration zones of +-+- on, FIG. 3(B) shows the case in which there are three node lines of 3rd order which partition the plane into six vibration zones of +-+-+-, and FIG. 3(B) shows the case in which there are four node lines of 4th order which partition the plane into eight vibration zones of +-+-+--+.

SUMMARY OF THE INVENTION

[0018] The present invention is made on the light of the problem mentioned above, the objective is to provide a gas turbine and the combustor thereof in which super high frequency combustion oscillation and the generation of NO_x are reduced.

[0019] To be more specific, since said combustion oscillation is the coupled vibration of the pressure fluctuation in the acoustic system and the fluctuation in heat liberation in the combustion system, the present invention aims at providing an art to achieve said objective particularly by suppressing said combustion oscillation through suppressing the pressure fluctuation which induces the fluctuation in heat liberation.

[0020] The present invention intends to solve the problem by providing a gas turbine comprising a combustor which is provided with a plurality of main fuel supply nozzles, each nozzle having a premixing nozzle at the top end part thereof, around a pilot burner located on the center axis of a flame tube; composed so that the air compressed by the air compressor of the gas turbine is introduced into the combustor as combustion air; and comprising a sound pressure suppressing means for suppressing the propagation of sound pressure in the direction along a section transversal to the axis of the combustor in the circumferential direction around the axis thereof while allowing the free flow of air passing therethrough provided in the space where said premixing nozzles are located or in the space upstream therefrom. Particularly, said combustor of the gas turbine is provided with a sound pressure suppressing means for suppressing the propagation of sound pressure in the direction along a section transversal to the axis of the combustor in the circumferential direction around the

axis thereof while allowing the free flow of air passing therethrough provided in the space where said premixing nozzles are located or in the space upstream therefrom. Said sound pressure suppressing means is one or a plurality of partition members with many holes, which partition the space around one or a plurality of premixing nozzles or the space upstream therefrom along the axial direction of the combustor; or a honeycomb like element having air passages in the axial direction of the combustor, the element being provided in the space around one or a plurality of premixing nozzles or in the space upstream therefrom; or premixing nozzles, each of the nozzles being composed of a porous cylindrical element.

[0021] Said sound pressure suppressing means may be a combination of said premixing nozzles composed of porous cylindrical elements and said partition members with many holes or said honeycomb like element.

[0022] The present invention is explained below.

[0023] It is thought that said fluctuation in heat liberation is due to the fluctuation in the state of mixing of fuel and air at the premixing nozzles and this fluctuation is propagated through the premixing nozzles to the upstream side. The combustion oscillation of super high frequency is a plane vibration having nodes on the planes orthogonal to the axis of the flame tube, i.e. plane mode vibration as shown in FIG. 3, so interaction between the nozzles occurs also in the upstream side of the premixing nozzles. By preventing or restricting the propagation of the sound pressure of this part by partition plates such as plates with many holes or pressure shield plates, the suppression of the propagation of sound pressure in the direction along a section transversal to the axis of the combustor (cluster of premixing nozzles) in the circumferential direction around the axis thereof is possible and the super high frequency combustion oscillation can be suppressed.

[0024] As said partition plates are, for example, plate having many holes, sound pressure is shielded but air flows freely. The principle of sound pressure reduction of the plate with many holes is that the sound pressure energy is reduced due to the resistance by the holes. There is no particular restriction about the plate with many holes 35 so far as it shields the sound pressure and allows air to pass through. For example, it may be formed of punched-metal, steel meshwork, sintered ceramic, sintered meshwork of stainless steel or heat-resisting steel, etc.

[0025] As the plate with many holes 35 are provided between adjacent premixing nozzles, it is preferable to locate the plates in each space between adjacent premixing nozzles so that the number of plates with many holes 35 corresponds with the number of the premixing nozzle. However, it is not necessary, depending on the sound mode, that they are located between adjacent nozzles, one plate nozzles may be located for each of two premixing nozzles, or the plates may be located at 2 · 1 · 2 · 1 intervals of the premixing nozzles.

There may occur the case an odd number of the plates are provided for an even number of the premixing nozzles, or an even number of the plates are provided for an odd number of the premixing nozzles. The plates with many holes may be located between adjacent premixing nozzles at an equal interval or at unequal intervals.

[0026] Further, by forming the premixing nozzles of porous material so as to suppress the fluctuation in the state of fuel/air mixing at the premixing nozzles, the propagation of sound pressure in the direction along a section transversal to the axis of the combustor (cluster of premixing nozzles) in the circumferential direction around the axis thereof be further more suppressed, resulting in the suppression of the super high frequency oscillation of combustion.

[0027] It is also suitable that the space where said premixing nozzles are located or the space of its upstream side is stuffed with a honeycomb like element having air passages in the axial direction of the combustor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

FIG.1(A) is a longitudinal sectional view showing the inner structure of the combustor of first embodiment according to the present invention, FIG.1(B) is a cross sectional view thereof.

FIG.2 (A) is a longitudinal sectional view showing the inner structure of the combustor of second embodiment according to the present invention, FIG.2 (B) is a cross sectional view thereof.

FIG.3(A) are illustrations showing modes of the sound pressure in the combustor, (A) shows the case in which there are two node lines of 2nd order, (B) shows the case in which there are three node lines of 3rd order, and (C) shows the case in which there are four node lines of 4th order.

FIG.4(A) is a longitudinal sectional view showing the inner structure of the combustor of the first example of prior art, FIG.4(B) is a cross sectional view thereof.

FIG.5(A) is a longitudinal sectional view showing the inner structure of the combustor of the second example of prior art, FIG.5(B) is a cross sectional view thereof.

FIG.6 is a longitudinal sectional view of a gas turbine near the combustor, the combustor of the present invention and the prior art being applicable to the gas turbine.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0029] A preferred embodiment of the present invention will now be detailed with reference to the accompanying drawings. It is intended, however, that unless par-

ticularly specified, dimensions, materials, relative positions and so forth of the constituent parts in the embodiments shall be interpreted as illustrative only not as limitative of the scope of the present invention.

[0030] FIG.1(A), (B) are schematic illustrations of a combustor in which diffusion combustion is combined with premixed combustion, FIG.1(A) is a longitudinal sectional view showing the inner structure of the combustor of first embodiment according to the present invention, and FIG.1(B) is a cross sectional view thereof.

[0031] In the drawings, The combustor is composed of a pilot burner 20 for diffusive combustion provided on the center axis of a substantially cylindrical flame tube (liner) 16, the pilot burner 20 being provided with a pilot fuel supply nozzle 13 having a pilot swirler vane 21 attached around the top end part of the pilot fuel supply nozzle 13; and premixed combustion burners 30 having eight main fuel supply nozzles 12a, ... arranged surrounding the pilot burner 20, premixing nozzles 14, ... being arranged around the top end part each of the main fuel supply nozzles 12a, ..., a disk-like nozzle plate 17 and a premixing swirler vane 15, ... being provided in the annular space between each of the main fuel supply nozzles 12a, ... and premixing nozzles 14, ...

[0032] Pilot fuel is supplied from the pilot fuel supply nozzle 3, combustion air for burning the pilot fuel is supplied from around the pilot nozzle to effect pilot combustion which is of diffusive flame in the central part of the combustor. Around the pilot flame is supplied fuel/air mixture of very high air excess ratio to be contacted with the high temperature gas of the pilot flame so as to effect main combustion composed of premixed flames (main flames). This is the same as the case of combustor of the prior art. To be more specific, in the gas turbine combustor, pilot fuel is supplied from the pilot fuel supply nozzle 13 extending along the center axis of the flame tube 16, and a pilot air supply passage 22 is formed around the pilot fuel supply nozzle 13. A pilot swirler 21 for holding flame is provided in the pilot air supply passage 22. Further, main fuel supply nozzles 12a, ... for supplying the fuel for main combustion, main air supply passages 23, ..., and premixing swirl vane 15, ... are provided around the pilot air supply passage 22.

[0033] The pilot fuel supplied from the pilot fuel supply nozzle 13 mixes with the air supplied through the pilot air supply passage 22 to be burned at the outlet side of the passage, and a pilot flame of high temperature is formed. The fuel supplied from the main fuel supply nozzles 12a, ... mixes with the air supplied through the main air supply passage 23 in the mixing zones formed downstream from the premixing nozzles 14, ... to be formed into fuel/air mixture. The fuel/air mixture contacts with the pilot flame, and the main flame 18 is formed. In the drawing, reference numeral 11a and 11b show airflow.

[0034] The combustion oscillation generated in a combustor of the structure like this is the coupled vibration of the pressure fluctuation in the acoustic system and the fluctuation in heat liberation in the combustion

system. According to the present invention, particularly the pressure fluctuation which induces the fluctuation in heat liberation can be suppressed.

[0035] It is thought that the fluctuation in heat liberation is due to the fluctuation in the state of mixing of fuel and air at the premixing nozzles and this fluctuation is propagated through the premixing nozzles to the upstream side. The combustion oscillation is of super high frequency and is a plane vibration having nodes on the planes orthogonal to the axis of the flame tube, i.e. plane mode vibration as shown in FIG.3, so interaction between the nozzles occurs also in the upstream side of the premixing nozzles 14.

[0036] Therefore, in an embodiment of the present invention, the propagation of sound pressure on the planes orthogonal to the axis of the flame tube is prevented or restricted by partitioning with plates 35 having many holes provided in the space between the adjacent premixing nozzles 14, 14 or the space between the adjacent premixing nozzle 14, 14 in the upstream side.

[0037] There is no particular restriction about the plate with many holes 35 so far as it shields the sound pressure and allows air to pass through. For example, it may be formed of punched-metal, steel meshwork, sintered ceramic, sintered meshwork of stainless steel or heat-resisting steel, etc.

[0038] Said plates with many holes 35 are located extending in the longitudinal direction along the airflow from the opening for air intake 16a of the flame tube to the root of the premixing nozzles 14, i.e. upstream from the premixing nozzles 14 and extending radially from the periphery of the pilot fuel supply nozzle 13 to the inner radius of the flame tube 16 in the spaces between adjacent premixing nozzles.

[0039] To be more specific, when eight premixing nozzles are provided from the position deviated by 22.5° from a vertical line in the circumferential direction at 45° interval as shown in FIG.1(B), eight plates with many holes 35 are located radially at 45° interval in the vertical, horizontal, and two slanting directions.

[0040] By providing the plates with many holes 35 like this, each longitudinal space around each premixing nozzle 14 is partitioned into each independent space along each premixing nozzle 14. Therefore, air can flow through each independent space but the propagation of sound pressure in the direction along a section transversal to the axis of the combustor in the circumferential direction around the axis thereof can be suppressed. Accordingly, the occurrence of interaction between the premixing nozzles and the propagation of the sound pressure due to the interaction is prevented, resulting in the suppression of the super high frequency combustion oscillation.

[0041] As the plates with many holes 35 are provided between adjacent premixing nozzles, it is preferable to locate the plates in each space between adjacent premixing nozzles so that the number of plate with many holes 35 corresponds with the number of the premixing

nozzle. However, one plate may be located for each of two premixing nozzles, or the plates may be located at 2 · 1 · 2 · 1 intervals of the premixing nozzle. In this case, there may occur the case in which an odd number of the plates are provided for an even number of the premixing nozzles, or an even number of the plates are provided for an odd number of the premixing nozzles.

[0042] The plates with many holes 35 are located between adjacent premixing nozzles at an equal interval of 45°, however, it is suitable to provide at different interval, for example, at interval of 40° / 50° / 40° / 50°, depending on sound pressure mode.

[0043] Further, by forming the premixing nozzle 14 into a cylindrical component with many holes 14a by utilizing porous ceramic material or porous material such as sintered metal, the fluctuation in the state of fuel/air mixing at the premixing nozzles 14a is suppressed by said cylindrical component with many holes 14a while maintaining smooth airflow in the axial direction, and the propagation of sound pressure in the direction along a section transversal to the axes of the premixing nozzles 14, 14 in the circumferential direction around the center axis of the flame tube 16 is suppressed, resulting in suppressed combustion oscillation of super high frequency.

[0044] FIG.2 is another embodiment of the combustor in which a honeycomb like element 40 having a large number of air passages 41 in the axial direction is provided in the space where the premixing nozzles are arranged or in the upstream part thereof. Said honeycomb like element 40 is located inside the flame tube 16 extending from the opening for air intake 16a of the flame tube 16 to the root of the premixing nozzle 14, the air passages 41 extending along the direction of air flow in the axial direction.

[0045] In the embodiment, the upstream side of the premixing nozzles 14 is subdivided into a large number of independent air passages by said honeycomb like element 40, the propagation of sound pressure in the plane orthogonal to the axis of the flame tube is effectively prevented, while the air flows freely through the air passages 41.

[0046] As has been described in the foregoing, according to the present invention, the propagation of sound pressure in the direction along a section transversal to the axis of the combustor (cluster of premixing nozzles) in the circumferential direction around the axis thereof can be suppressed. As a result, super high frequency combustion oscillation can be suppressed.

Claims

1. A combustor for a gas turbine comprising:

a plurality of main fuel supply nozzles provided around a pilot burner located on the center axis of a flame tube, each main fuel supply nozzle having a premixing nozzle at the top end part

thereof, and
a sound pressure suppressing means for suppressing the propagation of sound pressure in the direction along a section transversal to the axis of the combustor in the circumferential direction around the axis thereof while allowing the free flow of air passing therethrough provided in the space where said premixing nozzles are located and/or in the space upstream therefrom.

2. The combustor for a gas turbine according to claim 1, wherein said sound pressure suppressing means comprises one or a plurality of partition members with many holes, which partition the space around one or a plurality of premixing nozzles or the space upstream therefrom along the axial direction of the combustor.
3. The combustor for a gas turbine according to claim 1, wherein said sound pressure suppressing means comprises a honeycomb like element having air passages in the axial direction of the combustor, which is provided in the space around one or a plurality of premixing nozzles or in the space upstream therefrom.
4. The combustor for a gas turbine according to claim 1, 2 or 3, wherein said sound pressure suppressing means comprises said premixing nozzles, each of which is composed of a porous cylindrical element.
5. A gas turbine comprising
an air compressor; and
a combustor as defined in any one of claims 1 to 4,
wherein said combustor is provided so that the air compressed by the air compressor is introduced into the combustor as combustion air.

Fig 1 (B)

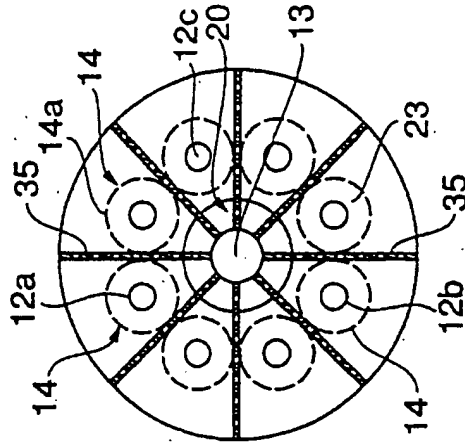


Fig 1 (A)

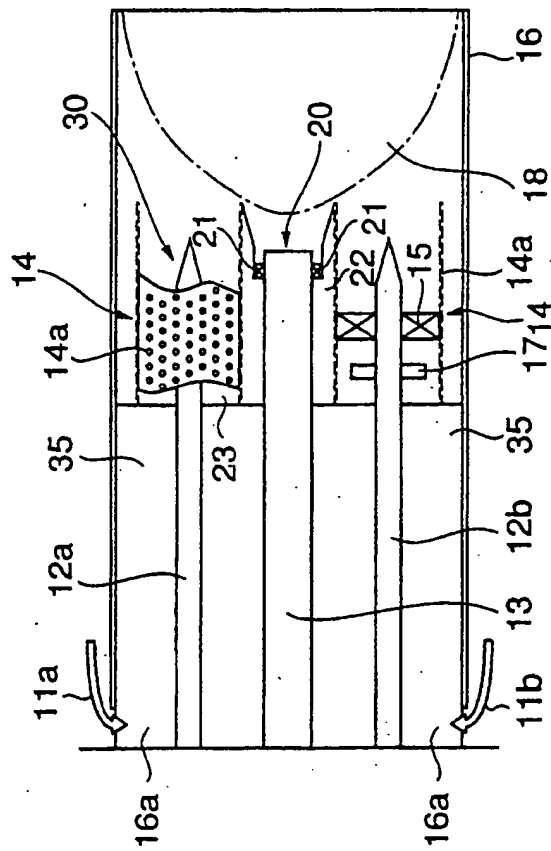


Fig 2 (A)

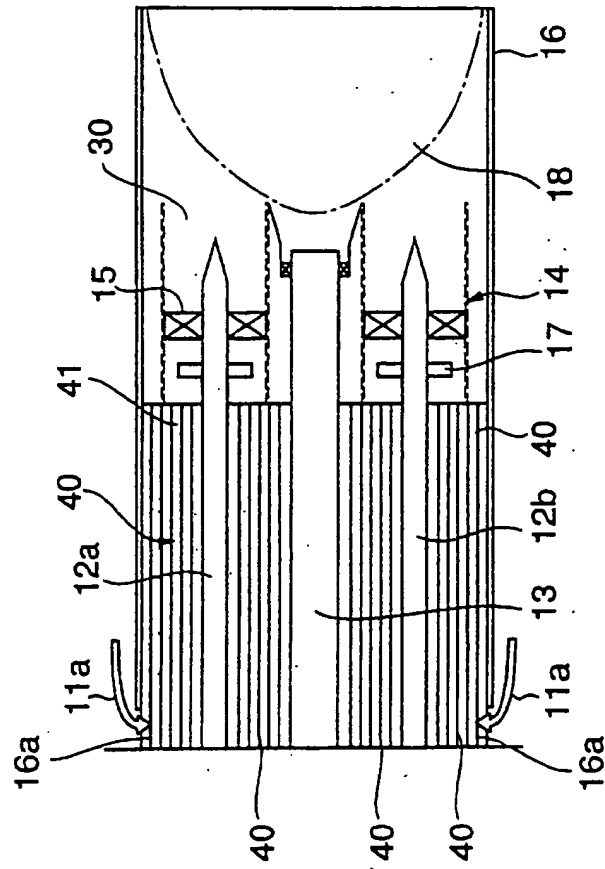


Fig 2 (B)

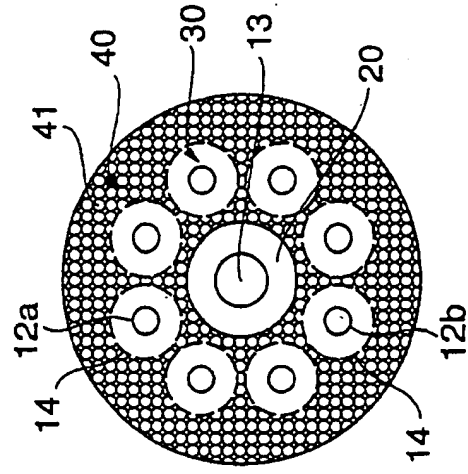


Fig 3 (A)

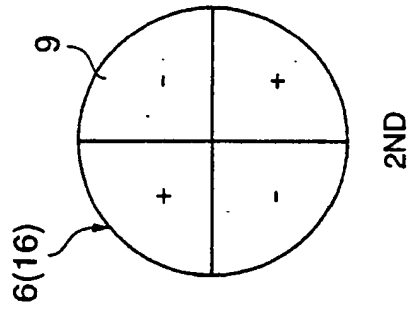


Fig 3 (B)

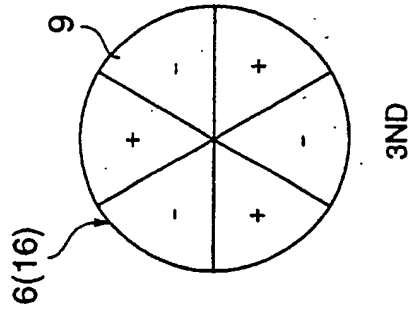


Fig 3 (C)

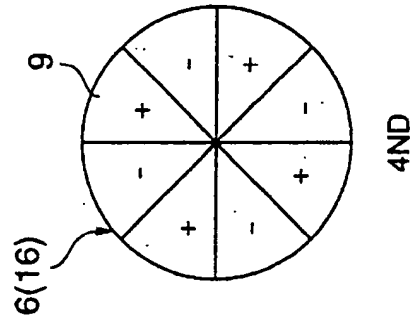


Fig 4 (B)

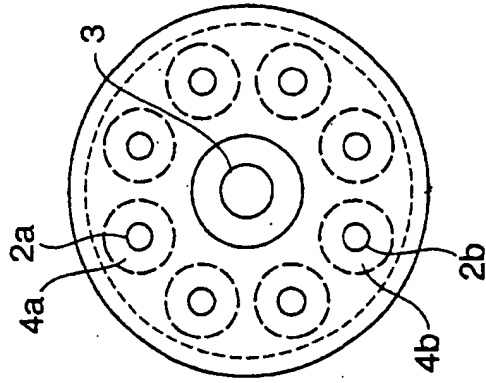


Fig 4 (A)

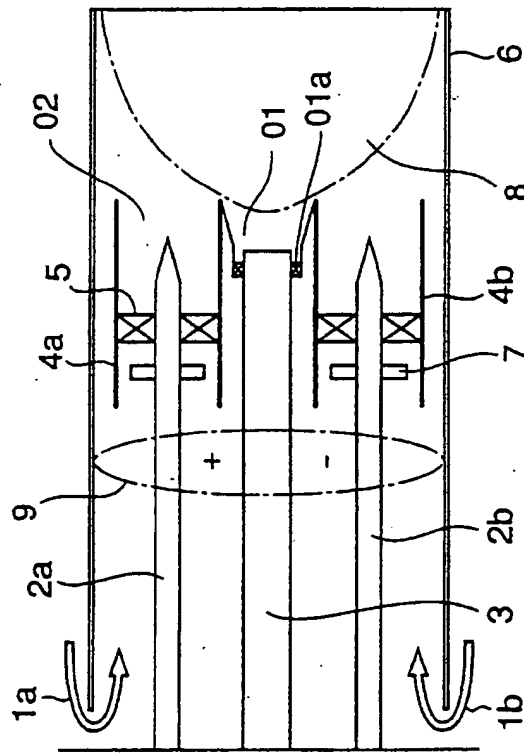


Fig 5 (A)

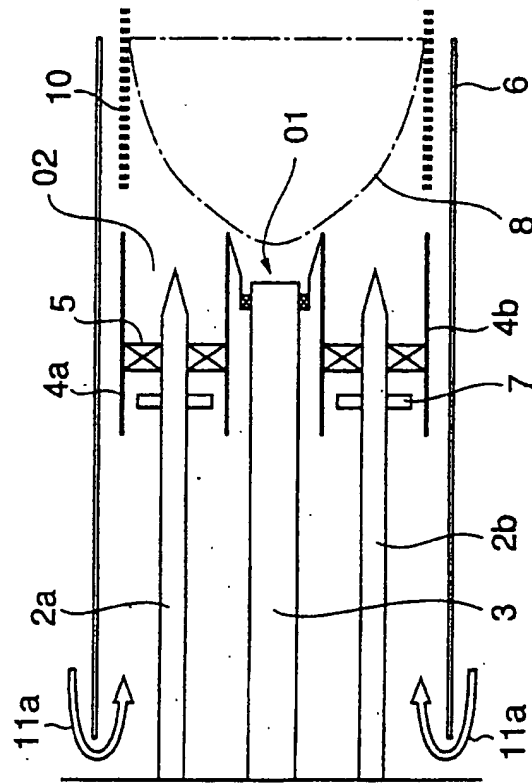


Fig 5 (B)

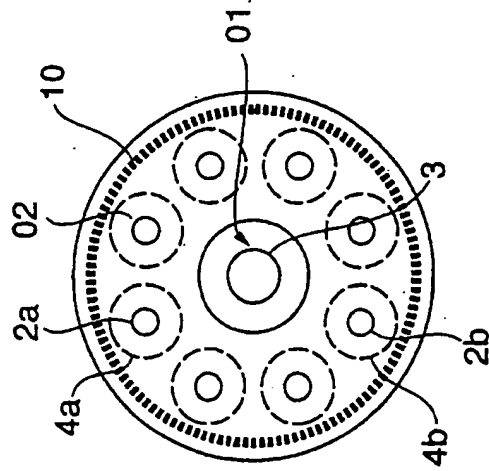
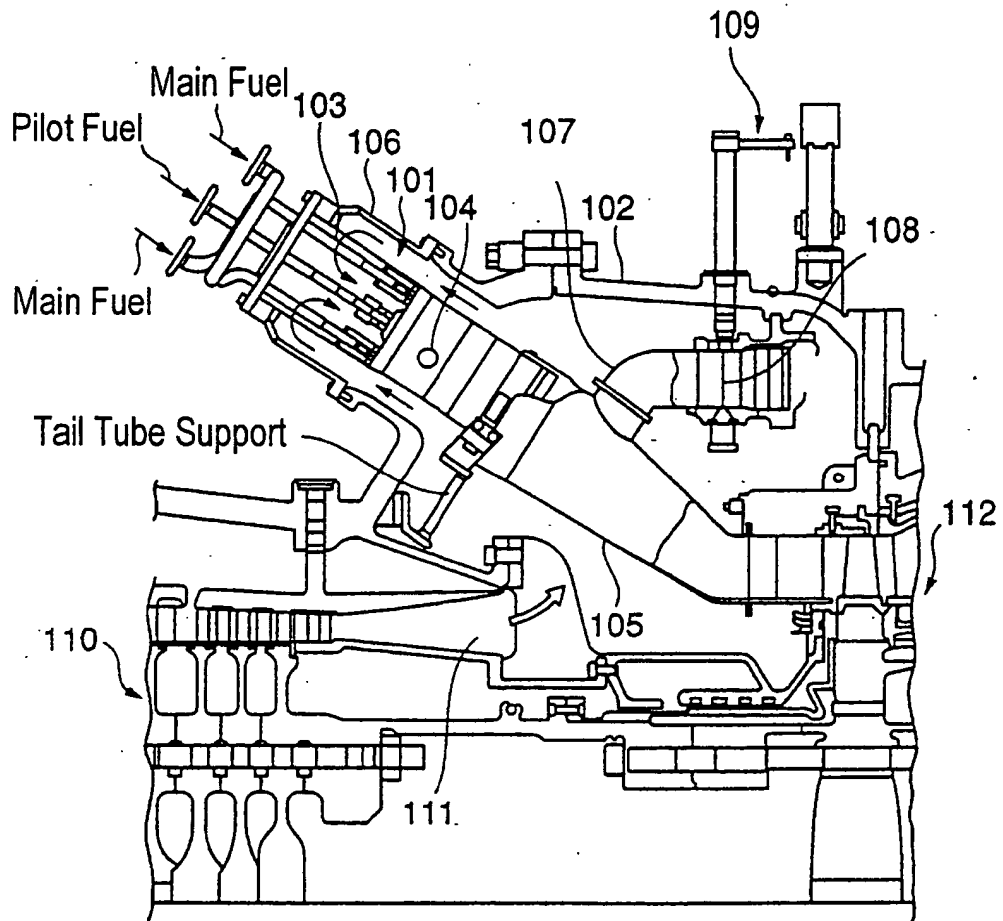
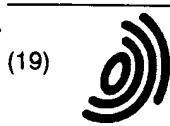


Fig 6





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- Tanaka, Katsunori, Takasago Machinery Works
Arai-cho, Takasago-shi, Hyogo-ken (JP)
- Ikegami, Yasuhiko, Takasago R&D Center
Arai-cho, Takasago-shi, Hyogo-ken (JP)
- Ono, Masaki, Takasago R&D Center
Arai-cho, Takasago-shi, Hyogo-ken (JP)
- Ikeda, Kazufumi, Takasago R&D Center
Arai-cho, Takasago-shi, Hyogo-ken (JP)

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(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo (JP)

(72) Inventors:
• Matsuyama, Kelsuke, Takasago R&D Center
Arai-cho, Takasago-shi, Hyogo-ken (JP)

(74) Representative: **Henkel, Feller, Hänzel**
Möhlstrasse 37
81675 München (DE)

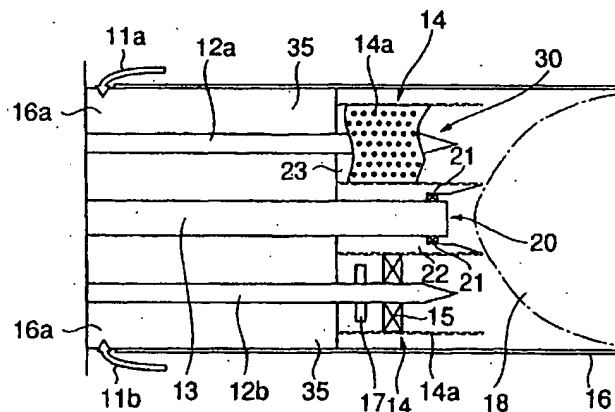
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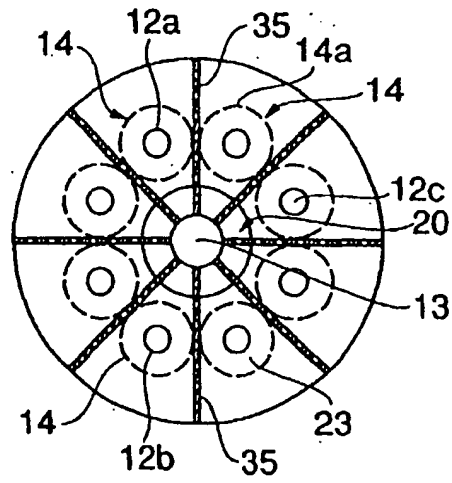
nozzles (12a), each having a premixing nozzle (14) at the top end part thereof, by providing in the space upstream from the premixing nozzles partition elements (35) for dividing the space along the axis of the combustor or a honeycomb element having air passages in the axial direction, or by providing premixing nozzles composed of cylindrical elements with many holes (14a).

Fig 1 (A)



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Fig 1 (B)





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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 373 695 A (URECH RAPHAEL ET AL) 20 December 1994 (1994-12-20) * column 2, line 59 - column 5, line 37; figures 1-4 *	1	F23R3/28 F23R3/34 F23M13/00
A	US 5 644 918 A (DEAN ANTHONY JOHN ET AL) 8 July 1997 (1997-07-08) * column 2, line 26 - column 3, line 56; figures 1,2 *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 10, 31 August 1999 (1999-08-31) & JP 11 141878 A (MITSUBISHI HEAVY IND LTD), 28 May 1999 (1999-05-28) * abstract *		
A	EP 0 899 506 A (ABB RESEARCH LTD) 3 March 1999 (1999-03-03) * page 3, line 42 - page 4, line 50; figures 1-3 *		TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	EP 0 564 183 A (GEN ELECTRIC) 6 October 1993 (1993-10-06) * column 3, line 29 - column 6, line 40; figures 1-4 *		F23R F23M F23D
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 29 October 2003	Examiner Theis, G
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ON EUROPEAN PATENT APPLICATION NO.**

EP 02 01 9089

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29-10-2003

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5373695	A	20-12-1994	EP 0597138 A1	18-05-1994
			DE 59208715 D1	21-08-1997
			JP 3397858 B2	21-04-2003
			JP 6221563 A	09-08-1994
US 5644918	A	08-07-1997	NONE	
JP 11141878	A	28-05-1999	NONE	
EP 0899506	A	03-03-1999	DE 19737998 A1	04-03-1999
			EP 0899506 A2	03-03-1999
EP 0564183	A	06-10-1993	US 5239818 A	31-08-1993
			CA 2089296 A1	01-10-1993
			DE 69312362 D1	28-08-1997
			DE 69312362 T2	19-02-1998
			EP 0564183 A1	06-10-1993
			JP 2060677 C	10-06-1996
			JP 6018034 A	25-01-1994
			JP 7088947 B	27-09-1995

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